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Sustainable Energy Technology in Southern Societies

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Preface

In order to prepare for the 1995 Conference of Parties (CoP) of the Framework Convention on Climate Change (FCCC), the World Wide Fund for Nature (WWF) requested the Institute for Environmental Studies in Amsterdam to conduct a study in collaboration with the Tata Energy Research Institute in Delhi.

As indicated in the FCCC, the developed countries commit themselves to returning to their 1990 levels of anthropogenic emissions of carbon dioxide and other greenhouse gases (FCCC, Article 2.2b). The emissions of carbon dioxide contribute significantly to the possible enhanced greenhouse effect. The burning of fossil fuels is seen as the largest source of carbon dioxide emissions.

Although developed countries have the first obligation to reduce their emissions, the present report focuses on contributions to be pursued by developing countries. In the FCCC developed countries have indicated to assist developing countries by transfers of financial means and advanced appropriate technologies on favourable terms. For this purpose practical modalities are currently being developed.

In attempting to contribute to such modalities, the present study has a two-fold objective. First, it explores cultural and economic constraints to low carbon and renewable energy technology in developing countries. Second, it attempts to convert these findings into a policy recommendation for the Conference of Parties of the FCCC.

The report is based on a review of literature, expertise available at the Institute for Environmental Studies (IES) in Amsterdam, and the Tata Energy Research Institute (TERI) in Delhi. The results of brainstorm meetings held at TERI and IES are included.

Sharmila Barathan, Pankaj Bhatia and Girish Sethi of TERI wrote chapter 4, *Focus on India*, and the appendices A.3 and A.4. The other parts were provided by Roebijn Heintz and Peter van der Werff of IES. Peter van der Werff took care of the editing. Contributions in content, editing and organization were given by Paul Hassing, Pier Vellinga, Onno Kuik, Joyeeta Gupta, Pieter van Beukering, Ajit Mathur and Pradeep Dadhich. The authors assume responsibility for the final version of the report. A shorter version, without the appendices, is published by the World Wide Fund for Nature (WWF) International.

Summary

Strategies for energy efficiency and renewable energy in southern countries should be based on domestic capacity building. A trend towards more sustainable technology should be generated within the southern societal systems and be applied in economic production, family households, and environmental management.

Certain imported technologies, priorities and styles of management remain anomalies, or *white elephants*, in the receiving southern countries. There, cultural, behaviourial and economic patterns are geared towards solving other problems than climate change which became perceived as a problem by northern observers only recently.

Consequently, southern energy actors have to deal with the frictions between imported and domestic technologies, priorities and styles of management. Decisions of southern actors may partly be geared by *non-mechanistic* thinking, whereas *mechanistic* thinking constitutes the basis of modern sustainable energy technologies, management practices and international policies. Discrepancies occur in the dissemination of information, enforcement of the law and environmental awareness.

Economic problems arise when imported technologies create inconsistencies between capital intensity, input requirements of the technology, and the resource and skill endowments of a country. Moreover, many imported technologies fail to fit in with the capital-labour mix. The developing countries typically lack in capital but have considerable labour resources at their disposal. Domestic research and development is insufficiently stimulated by technology transfers.

Certain international technology transfers, through trade, direct investment and aid are integrated in the southern systems. However, both their selection and diffusion require much prudence and should take place at the end of problem solving processes. Constraints to desired sustainable energy technologies are found in high costs for private purchasers, lack of foreign currency, insufficient availability of sustainable energy technologies, a lack of information, and risks in domestic contracting.

The study concludes that climate related funds of the Global Environmental Facility should concentrate primarily on human resource development in southern countries. The GEF should generate conditions for southern societies to develop, apply and absorb energy efficient and renewable energy technology and management. It is proposed to realize this objective by creating environmentally sound energy agencies (ESEAs) in southern countries.

1. Introduction

This report focuses on ways to reach efficient usages of fossil fuel-based energy and the innovation and application of renewable energy sources in the southern countries. Such more sustainable energy strategies cannot be applied in *tabula rasa*, or *empty* situations. They have to fit in with existing patterns of thinking and behaviour of the *energy actors*, the producers and consumers of energy. The understanding of these energy actors and their societal systems is a prerequisite for effective sustainable energy policies.

Therefore, this report emphasizes domestic capacity building to facilitate sustainable energy production and consumption. However, this capacity building should not become a goal in itself. Any modifications in behaviour and thinking should actually result in sustainable energy production and consumption.

Both national and international conditions operate as constraints and opportunities for the relevant capacity building. Nationally, the societal systems have to dynamize a trend towards more environmentally sound technology. This trend can pervade technological innovation and diffusion, economic production, family households, and environmental management.

Certain international technology transfers are integrated in the local systems and facilitate a desired technological development. However, many imported technologies remain anomalies in the receiving societies. These so-called *white elephants* do not fit into the existing systems of technology, production, consumption and environmental management and control. Knowledge of success and failure of earlier technology transfer through trade, direct investment and aid need to be incorporated in energy policy making.

International technology transfer has also been a central issue at the United Nations Conference on Environment and Development (UNCED) and the United Nations Framework Convention on Climate Change (FCCC). In southern countries these new arrangements for transfer of energy technology became part of the ongoing debate on white elephants. Some southern parties have interests in technology imports, others suggest the risk of dumping of northern technologies, and an underestimation of *white elephant* problems and differences in cultural, behaviourial and need patterns.

Outline of the report

In view of the above considerations, this report focuses on societal and economic constraints to low carbon and renewable energy technology in developing countries. It studies North-South transfers of technology in their capacity to contribute to this goal. Consequently, it attempts to convert these findings into an elaborated policy recommendation for the Conference of Parties of the FCCC.

Chapter 2, *Technology in southern societies*, reviews constraints to the development of software technology and enabling human capacities in developing countries. Chapter 3, *Transfer of technology*, describes channels of technology transfer and constraints operating in these channels. Chapter 4, *Focus on India*, summarizes the two case studies as presented in the appendix, and provides conclusions about energy technology in India.

Chapter 5, *Southern requirements summarized*, reviews point by point the conclusions from chapters 2-4. Chapter 6, *Elaborated policy recommendation*, translates the main conclusions into the one single, elaborated recommendation about domestic capacity building.

Appendix A.1 provides relevant definitions. Appendix A.2 is based on a review of literature. First, it evaluates interactions between imported technologies and domestic systems. Second, it provides factual information about the most important channels of North-South transfer of technology. Third, it reviews various constraints to imports of desired sustainable energy technologies.

The last two appendices report on two cases studies conducted by TERI in India. Appendix A.3 reviews the technology of power cogeneration in the Indian sugar industry. Appendix A.4 concerns the Indian refrigerator industry and the technology cooperation with a Japanese firm.

2. Technology in southern societies

Modern technologies, priorities and styles of management for sustainable energy are imported from the North and differ from conditions in the South. There, cultural and behaviourial patterns are geared towards solving other problems than climate change which became perceived as a problem by northern observers only recently.

Consequently, southern energy actors have to deal with the frictions between imported and domestic technologies, priorities and styles of management. Several North-South discrepancies are identified as constituting obstacles towards the development of human resources needed for environmentally sustainable energy technologies.

Decisions of southern actors may partly be geared by *non-mechanistic* thinking, whereas *mechanistic* thinking constitutes the basis of modern sustainable energy technologies, management practices and international policies

The non-mechanistic preference of face-to-face communication and negotiation tactics hampers the dissemination of information based on mechanistic telecommunication and the assumption of neutrally operating institutions

Southern governments may be organized in northern styles but operate non-mechanistically. Furthermore, they are not prepared to design integrated energy policies. The raising of a northern type of awareness needed for modern environmental policies is still to be developed.

2.1 Domestic capacity building

According to its wider definition, technology includes not only *hardware*, but also *software* in the form of technical skills. In the energy sector, the involved actors engage in power supply, transmission and consumption by enterprises and households, transport, cooking and heating. Their skills determine good housekeeping, repair, maintenance, research and development (R&D) and imports of energy technologies in utilities, business firms and family households. Communication about hardware and software may suffer from inadequacies of information systems, costs, available hardware and training of skills

The process of human resource development, however, implies more than just technical skills of the actors involved. It builds on cultural and behaviourial patterns of these *energy actors* favourable to sustainable energy technology It modifies the social patterns in the areas of management of technology, knowledge infrastructure, customs of environmental checks and balances, and structures of economic supply and demand.

Endogenous technologies have the advantage of being historically integrated with the physical environment and other human capacities. However, modern energy production and consumption require a reorientation in human capacities. A trend towards self-improvement and the overcoming of cultural and behaviourial barriers depend on adequate research, information, school education, child rearing, activism, rules and regulations, jurisdiction, and informal control.

Literature and expertise available suggest that the raising of awareness constitutes a basic influence on sustainable energy behaviour. In situations where economic and legal instruments find insufficient enforcement, the societal environment can enable the development of climate friendly technology by raising awareness. The economic environment often forms a barrier by generating high costs of sustainable technologies, thereby precluding the maximization of profits in the private energy sector. Increasing the costs of carbon intensive technologies by incorporating environmental costs in energy prices and terminating the subsidies for the use of fossil fuels is rather absent.

2.2 Technology at the cultural interface

Policy technologies, priorities and styles of management aiming at the control of carbon energy emissions are imported from the North and are therefore often very different from conditions in the South. Consequently, southern societies and actors, including energy actors, have to deal with the frictions between imported and domestic technologies, priorities and styles of management.

The uneasy interactions occur at what can be called the *cultural interface*. One of the relevant differences is between the mechanistic and non-mechanistic thinking and behaviour. Decisions of southern actors may partly be geared by non-mechanistic thinking, whereas mechanistic thinking constitutes the basis of modern sustainable energy technologies, management practices and international policies.

Mechanistic thinking largely shapes the northern notions of energy efficient management and innovation of alternative energy sources. This mechanistic thinking emphasizes rationality, linearity, focus, the objectification and control of nature, and the perceiving and solving of problems within the technological realm of life. Actors try to gain benefits through technological efficiency and innovation.

Non-mechanistic thinking allows both rationality and emotionality, and implies subjective, holistic and diffuse experiences of time and space, including the physical environment. It concentrates on human beings and their interactions, and perceptions and solutions of societal problems. Actors try to gain benefits through the sophistication of dealings with other people (cf Holmstrom 1985, Jacob 1994, Shiva 1988, Van der Werff 1994).

As indicated above, not only differences but also interactions between mechanistic and non-mechanistic thinking, notably in southern societies are to be considered. On such type of interaction at the cultural interface, and a highly relevant one here, regards attempts to westernize information dissemination. The persisting non-mechanistic preference of face-to-face communication, then, can constitute a serious obstacle to the improvement and use of information systems which are based on mechanistic telecommunication and the assumption that dissemination will be pursued without particularistic motives. More likely is, that northern derived sustainable energy knowledge and hardware are used as trade offs in negotiation tactics rather than as the neutral basis for further innovation and diffusion.

Southern government institutions and judiciaries, although inherited from the North, largely operate non-mechanistically. Funds, staff, economic instruments and legal instruments to control unsustainable technology or stimulate sustainable technology may be used for negotiation purposes, rather than for mechanistic ways of enforcing the law and concentrating on hardware and technological efficiency.

Internationally, the highly developed negotiation skills of southern countries may contrast with the northern focus on improvements of energy hardware. The subjectified experience of southern positions in the world community differs from the northern objectification of global environmental processes

3. Transfer of technology

3.1 The position of transfer

Several factors are identified as constraints to the international transfer of sustainable energy technologies. They occur in the fields of finance, availability, information, institutions, research and development, and regulations.

Domestic problems may arise when constraints to transfer are overcome, but the imported technologies insufficiently contribute to technical and institutional capacities in southern societies Too often the transfers regard only *hard* or *embodied* elements, or technology packages without enough *soft* or *disembodied* elements to facilitate domestic capacity building.

Certain circumstances in southern countries demand for the import of low carbon and renewable energy technologies. However both their selection and diffusion require much prudence and should take place at the end of problem solving processes.

Formulated in economic terms, processes of transfer imply interactions of international supply and demand which can be facilitated by removing constraints. Such constraints either preclude the transfer of technology in general, or cause purchasers to select carbon intensive technology.

Preferably, a technology contributes to consistency between capital intensity, input requirements of the technology, and resource and skill endowments of a country Moreover, technologies should fit in with the domestic cultural and behaviourial structures.

Many imported technologies fail to fit in with the capital-labour mix. The developing countries typically lack in capital but have considerable labour resources at their disposal. Globally, the optimal demand for sustainable technologies would be determined by a perfect market reflecting the effects of global warming in prices. In the absence of such a market that takes full account of the environmental effects of technology, the global demand for sustainable technologies is rather determined by the sum of all national policies and the outcome of international negotiations on climate change

3.2 Channels of technology transfer

Commercial channels

Much transfer of energy technology takes place through the commercial channels of trade and foreign direct investment At the national level, many transfers entail the risk that the supply does not match with priorities of developing countries. At the individual level, private purchasers prefer carbon intensive technologies to low carbon options as long as costs-benefit ratios of the latter remain relatively unfavourable. These private decisions seldom reflect national environmental costs. In the absence of a clear market for a particular technology, both parties will have to negotiate a price, which determines the distribution of benefits of this trade amongst the supplier and purchaser.

Purchasers of technology face several disadvantages There may be insufficient information about the nature of a certain technology, prices and alternatives available. Insufficient information before a purchase takes place may give rise to difficulties in managing the technology once installed.

Most southern countries have difficulties in attracting foreign direct investment. This is caused by their political, economic and technical climate unsuitable for long term investment. Moreover, foreign direct investment is influenced by a country's balance of payments and therefore, by the role of other financial flows, including the debt service.

Non-commercial channels

Technology can be transferred non-commercially through bilateral and multilateral governmental assistance, non-governmental organizations, and international compensation mechanisms. The second way to acquire technologies on a non-commercial basis is to make use of technologies that have passed into the public domain. Examples include technologies not transferred under patent restrictions, or based on information which is freely available, the attending of seminars, and the arranging of academic exchanges.

Just as commercial technology transfers, non-commercial transfers entail the risk that they do not match with the environmental interests of developing countries. Problems are funding of large, capital intensive projects and imports of northern technology disruptive to indigenous technology innovation and diffusion. Emphasis on transferring hardware rather than software technology, and tied assistance in lending arrangements can be added to this list.

In recent years, governmental aid flows are stagnating. Moreover, it is difficult to trace the substantial new and additional resources that the industrialized countries have promised to provide in the context of the FCCC

3.3 Constraints to technology transfer

Prominent constraints to transfers of technology are high financial costs for private purchasers, lack of foreign currency, lacking availability of sustainable energy technologies on the international market, quality of information, domestic access to information, and risks in domestic contracting.

At the individual level, both private and public energy actors prefer high carbon intensive technologies to low carbon options as long as cost-benefit ratio of the latter are unfavourable This is perhaps the most important constraint to the development of sustainable energy technology

Many developing countries are severely limited in their ability to acquire technology for various financial reasons. They face a lack of foreign exchange. Hence the opportunity costs of capital may be extremely high. The instability of commodity prices and ineffective stabilisation programmes perpetuate the situation (Rath 1993, ECOSOC 1994, Horino & Siy 1986)

Most multilateral and international lending institutions are technologically risk-averse. As a result, governments may be reluctant to invest in *high-tech* projects that entail high capital costs. Although many sustainable energy technologies imply profitable investments in the long term, upfront investments needed for major technological changes towards environmental sustainability remain lacking. Explanatory factors are also here a lack of capital and the short term interests of purchasers who have to operate in economic systems characterized by many uncertainties.

Communication between relevant parties, and education and training at both sides are often advocated but inadequate in practice. Proper support, training, operation, management, repair, post-evaluation and feed back may be lacking.

On the supply side, information may be lacking with respect to the potential of markets, and the range of potential buyers. In part this leads to an insufficient availability of sustainable energy technologies at international markets. On the demand side, energy actors in developing countries are often unaware of the type, variety and financial aspects of technologies available. International dissemination of information is hampered by lack of facilities and related skills. Domestically, the non-mechanistic negotiation culture may generate a tendency towards monopolizing rather than disseminating information (cf ECOSOC 1994).

Institutional constraints include a lack of integrated energy policies, weak linkages between government and industry, the ability to integrate new technologies with existing procedures, and domestic research and development institutions There may be a lack of banking and insurance facilities.

Southern governments insufficiently guarantee the enforcement of contracts. This generates artificially created delays, shortages and uncertainties in the supply of energy, raw materials and products, timely purchase, efficient public transport, construction, labour and payments (cf Van der Werff 1992).

Regulatory constraints operate in several ways. Consultancy and service contracts bought from industrialized countries as complete systems bring a prolonged technological dependency. Dependencies on suppliers inhibit adjustments to local circumstances and further development of the technology on the spot Multinationals may impose control over product choice and production methods Patent protection may constitute problems in transfers of new *high-tech* facilities (Touche Ross 1991, Almeida 1993, OECD 1992).

Three factors hampering southern research and development (R&D) are identified. Uncertainties in the economic systems operate to discourage long term investments, including for R&D regarding sustainable energy. The non-mechanistic world view implying a concentration on societal rather than technological solutions to gain benefits, precludes the innovation and diffusion of new energy technologies. Multinationals tend to concentrate R&D in their home country.

In developing countries, environmental policies and legislation are generally much less stringent than in the industrialized countries, and actual enforcement is a critical problem. Southern importers continue using technologies that do not take into account environmental interests, since they are more easily available and their use already familiar to producers.

4. Focus on India

4.1 Various industrial units

The technology in most industrial plants in India was built twenty to forty years ago. Some plants have had portions revamped, have introduced piecemeal new units, or contributed to an increase in energy efficiency by renewal of boilers, cogeneration units and heat recovery units. Most plants have not updated their processes or equipment to modern levels of technology on an integrated basis. There is a need to modernise many industrial facilities to increase energy efficiency, reduce emissions and increase competitiveness in world markets

A clearer picture is obtained if the status of technology, on an average, is examined in large scale industries, small and medium scale industries, and industries in the informal sector. Large scale industries are characterized by sophisticated and modern technologies. Efficiencies of large scale cement industries on par with the world's standards can be cited here. The small and medium scale industries, which constitute the most dynamic sector in India, are characterized by less energy efficient technologies. In the informal sector labourers are unskilled and work with simple, inefficient machinery. This is true in the case of tanneries, dye-houses, foundries, jaggery units, and repair shops.

4.2 Case studies

This report summarizes two case studies of improving energy efficiency and renewable energy conducted by TERI One regards the refrigerator industry and the other biomass based cogeneration in the sugar industry

Cogeneration in the sugar industry

Some earlier research on surplus power generation from the Indian sugar plants shows that its potential depends on two factors. Both the degree of efficiency improvements adopted by the mill and the boiler and turbo-generator configurations count. In 1993 the Task Force set up by the Ministry of Nonconventional Sources, Government of India estimated the potential of surplus power generation as 3436 MW by the end of the Eighth Five Year Plan in 1996-1997.

The case of biomass based cogeneration in the sugar industry reveals that indigenous capabilities for the design and manufacture of high pressure energy efficient boilers and turbines for cogeneration plants are limited. Low pressure and low temperature systems for steam and power generation are predominantly employed in the sugar industry in India

High pressure and high temperature cycles for cogeneration plant would require expert professionals to operate and manage the systems In addition, appropriate training for professionals to operate the cogeneration systems efficiently need to form an important

element of technology transfer. This suggests that all packages of technology transfer should thoroughly build in the component of capability development

It is difficult to raise the initial capital. Therefore, other investment promotion mechanisms are required. *Unpackaged* technology acquisition is preferred because India has competent technical and managerial manpower.

Perhaps the largest impediment for the development of cogeneration in the Indian sugar industry is the lack of clear policies by the central and state governments regarding the sale of cogenerated power to the grid. The ambivalence of the State Electricity Boards is explained by uncertainties about the supply of cogenerated power.

Constraints such as *technological inertia*, especially for older mills, in adopting the advanced cogeneration options, of course, do exist. However, once the sugar mills managers become fully aware of the enormous advantages, their reluctance to undertake plant modifications would be overcome.

The refrigerator industry

In the Indian refrigerator industry, indigenous technology development in the field of compressor design and development is absent. Thus, all compressor and refrigerator manufacturers have technology partnerships with foreign companies.

Field and laboratory tests of energy consumption show that the average energy consumption of Indian refrigerators falls short of the international standards and has much scope for technology upgrading With the rapid growth of the Indian economy and changing life styles of the Indian middle class, the refrigerator is increasingly considered a necessary household commodity rather than a luxury The demand in the refrigerator market is expected to grow at 20% per annum in the 1990s.

An analysis of energy savings and subsequent greenhouse gas emission abatement for production of the *165 lt* model refrigerator under two scenarios reveals that total savings are of the order of 26 and 54 million tonnes respectively, in the year 2005. The state-of-the-art technologies in this sector have the scope to reduce energy consumption by 10-25%.

4.3 Domestic capacity building

Domestic capacity building through technology transfers has been rather unsatisfactory sofar. In a study carried out on strategies and instruments to promote energy efficiency in Asia, it has been observed that both energy efficient use at the plant level and the implementation of policies show serious shortcomings arising from the lack of human resource development (ECN 1994)

Technology imported into developing countries hardly ever reaches its design capacity and its performance varies significantly over its operational life. A study conducted in Asia and Brazil reveals that in the energy and other sectors in the developing countries, in practice, the operating performance of many imported technologies does not even initially reach its potential as given in the design specifications, and subsequently follows

a decline that at best remains stagnant and at worst shows a considerable deterioration in performance (IAEE 1993).

This leads back to the aforementioned inference that technology transfer, in order to improve the rational use of energy, requires an intensive upgrading of the technology software component and the enabling environment: the development of human endowed capabilities.

One reason for the neglect of the human capability argument is the discrepancy of short term and long term interests. In the short run, costs of capability building are high. In economic environments where change is slow and investments risky, there is neither much incentive to make long run investments, either financial or in human endowed capability development. building. Another reason is the prolonged underestimation of North-South cultural differences in determining what is *efficient* management, and perceiving and solving technological problems.

Existing international financial mechanisms discourage long term relationships between technology vendors and buyers. Experience shows that they tend to be *ad hoc* and preclude the accumulation of experience and learning. This stems from the anarchic nature of international capital which seeks short term profit maximisation, quite in contrast to the long term stability of industrial capital (IAEE 1993).

Another point that warrants mentioning regards the necessary complementarity between imports of technology and domestic scientific and technological efforts. This again calls for availability of financial resources for the promotion of R&D activities either at the micro or macro level. In conjunction with this is the formulation of effective policies for initiating and pursuing R&D. A direct recommendation for policy making is that measures to increase the scope and depth of knowledge acquired by importing firms through collaborative agreements need to be strengthened.

While evidence clearly suggests that import of technology has often led to R&D activities and has increased the importing firm's technological capabilities, it does not imply that R&D activities by Indian firms are only carried out along with imports or that imported technology is a necessary condition for the growth of R&D activities.

4.4 Technology transfer

The scope for international co-operation in promoting the transfer of energy sound technologies essentially lies in four areas: 1) capacity building, 2) dissemination of information, 3) making available financial resources and 4) facilitating transfer of technology from the northern to southern countries.

One of the key concerns from a southern country's point of view is the lack of information. A recommendation could be that international organizations act as clearinghouses for coordinating exchanges. A role model could be that of the UNEP Industry and Environment Programme Activity Centre (IE-PAC).

Related to this is the development of local organizations. Existing centres need to be strengthened to ensure effective dissemination of information at the grass-root level. Monopolisation of information is common practice. When the secretary-general of the

national Chamber of Commerce informed local chambers of commerce of the existence of the International Chamber of Commerce's Environment Bureau (IEB), a number of distilleries got in touch to collect the relevant information. In India this drew the attention as something rather exceptional and a success story of how local organizations can play a key role

In the manufacturing sector the transfer of technology is perceived as *risky*. The compilation and dissemination of information about sale terms and prices is insufficient. This makes industrialists feeling unprepared for dealing with a large multinational supplier. Information dissemination based on demonstration projects is also insufficient.

The next concern is about financial mechanisms, without which the dissemination of information is rendered worthless. In addition to the new mechanisms of the FCCC - the Global Environmental Facility and joint implementation - there are various sources of financing technology transfer These are provided by commercial banks in the South and the North, multilateral development banks, and governments.

Generally, much technology transfer requires a facilitator or a middleman. More and better domestic facilitators are required because external facilitation often lacks modification in light of southern experience. Facilitators tend to focus on projects instead of programme assistance. In India this coincides with the emphasis on augmenting capacity in the power sector by scattered projects, whereas losses from transmission and distribution remain high are require a structural approach.

Indian buyers, when given the choice between capacity addition or energy conserving technology by domestic facilitators, choose environmentally sub-optimal technologies. Moreover, the facilitators do not dedicate themselves to the promotion of *best available retrofit technology* (BART) The Indian government does not invite for substantial improvements here.

5. Southern requirements summarized

The preceding chapters have explored requirements for reinforcing sustainable energy technology in southern societies. These field requirements are summarized below. Chapter 6 translates these requirements into an elaborated policy recommendation proposed to the Conference of Parties of the FCCC in March 1995

1. General requirements

1.1 In order to achieve sustainable energy targets, give top priority to capacity building of *energy actors* in the South.

1.2 Support the creation of enabling societal environments and endogenous technological developments.

1.3 Develop permanent programmes to raise environmental awareness and the understanding of *win-win* options beneficial to both economic and environmental interests.

1.4 Facilitate technology imports which suit the evolvement of enabling environments and sustainable energy development, and arrest other technology imports.

2. Energy actors

2.1 Aim policies at *energy actors* for the benefit of good housekeeping, repair, maintenance, and local research and development (R&D).

2.2 Facilitate public and private acquisition and dissemination of information on technical specifications, quality certification and economic feasibility of new technologies.

2.3 Review and further utilise experiences of successful sustainable energy R&D activities taking place in countries such as India and China.

3. Enabling environment

3.1 Review obstacles and improve national and international communication between actors in business communities, environmental management, education, information, research and activism.

3.2 Observe obstacles and improve information systems and access to them, including socio-political barriers, costs, available hardware and training.

3.3 Develop an integrated policy for an entire country.

3.4 Create a demand for sustainable energy supply.

3.5 Facilitate profit maximization with sustainable energy technologies in the private energy sector.

3.6 Support the development and implementation of techniques to raise environmental awareness in southern governments and citizens.

3.7 Acknowledge southern problems of the *cultural interface*: the interaction between imported technologies and southern categories of acting and thinking, systems of economic production and environmental management, power relations and perceived priorities.

3.8 Improve the understanding of southern non-mechanistic thinking and acting if these are to be adjusted to northern induced carbon technologies and policies. Acknowledge advantages and disadvantages of mechanistic thinking which dominates the innovation and diffusion of most technology, as well as international policy making.

4. Import of technologies

4.1 Apply experience gained in North-South cooperation in trade, joint ventures, multinationals, banking, official development aid, and non-governmental organizations.

4.2 Build skills of technology cooperation in both northern counterparts and southern energy actors, including governments and business communities.

4.3 Enlarge southern private sector demand of sustainable energy technologies by northern export subsidies and risk sharing arrangements.

4.4 Facilitate that technology imports fit the host country's economic factor mix, domestic market structure, and balances between public and private, large and small-scale, national and international firms.

4.5 Urge for technology import contracts which envisage domestic capacity building during the stages of design specification, opening performance and subsequent trajectory, to ensure the co-allocation of own resources and endogenous accumulation of technological capabilities.

4.6 Decrease the dependency from multinationals by enabling the purchase components of packages separately, particularly if resources are available domestically.

4.7 Improve international regulations with respect to intellectual property rights and relax unnecessary restrictions

4.8 Enhance the international access to technology by financial instruments in the commercial channel, and upgrade the access to information systems in the non-commercial channel.

4.9 Prevent northern companies and governments from using technology transfer as a means to *test* not yet matured technology. Demand that only matured technologies are transferred.

Elaborated policy recommendation to the FCCC

1. Central recommendation

The present study concludes that the climate related funds of the Global Environmental Facility should concentrate primarily on human resource development in developing countries. It should generate conditions for developing countries to develop, apply and absorb energy efficient and renewable energy technology and management.
This conclusion is proposed here as an elaborated policy recommendation to the Framework Convention on Climate Change. The recommendation might be used in the meeting of the Intergovernmental Negotiating Committee in February 1995 and the Conference of Parties in March 1995.
This recommendation fits in with the recommendation regarding of the Intergovernmental Negotiating Committee (18 January 1995, III.A, *Strengthening Technological Capabilities*). The proposed shift in the objective of the Global Environmental Facility would also reduce ongoing controversies concerning the principle of incremental costs.

2. Principles for the recommendation

The above recommendation is based on a set of principles drawn from the conducted study.

* Climate change policy making should primarily build on priorities for environmentally sustainable energy production and consumption in both northern and southern societies. Demand side energy efficiency and the development of renewable energy sources to control carbon dioxide emissions are important to reach this goal.

* In southern societies the development of human capabilities for environmentally sustainable energy technology is crucial.

* Southern societies have long-established patterns of environmental management, but these have to be adjusted for the effective coping with imported energy technology.

* Explicitly assessed local and national requirements should constitute the basis for cooperation in software and hardware energy technology.

* Northern government assistance, technology cooperation and technology transfer to southern countries is most effective when it supports human resource development and is not donor-driven

- As by far the larger part of technology cooperation and transfer takes place in the private sector, sustainable energy policies should include this sector.

- The Global Environmental Facility is only a first financial instrument to address climate change problems and attention has to be given to other financial institutions.

- The inclusion of sustainable energy loan conditions by multilateral development banks (MDBs) is unpopular with recipient countries. A new approach is advocated by which environmentally sustainable energy projects are submitted to MDBs.

- Developing countries should be encouraged to establish agencies for the promotion of environmentally sustainable energy, as further described below.

3. Environmentally sound energy agencies (ESEAs)

- The Global Environmental Facility should invite developing country cabinets to establish *environmentally sound energy agencies (ESEAs)* at the level of nations, federal states, provinces, or groups of small countries.

- These agencies should not be regarded as *buildings*, but as networks or groups of domestic experts representing the private, government and NGO sectors, who are successful in the field of environmentally sound energy technology

- The ESEAs should consolidate the public-private partnerships (PPPs) of government officials and industrialists, and include NGOs.

- These agencies could be either separate from planned environmentally sound technology centres (ESTCs), or coincide with these centres.

4. Human resource development by southern ESEAs

- The public, private and NGO partners in the ESEAs jointly submit project proposals to the Global Environmental Facility regarding domestic human resource development, which enables reaching the long term goal of environmentally sustainable energy technology.

- The ESEAs promote human resource development through any other means which enable the long term development of environmentally sustainable energy technology. Examples are listed below

- The ESEAs stimulate the design and distribution of educational packages for schools and universities

* The ESEAs stimulate environmental awareness raising among the wider public through radio and television.

* The ESEAs stimulate the creation of accessible terminologies in various regional languages.

* The ESEAs seek ways to overcome intercultural discrepancies which hamper the dissemination of information, energy efficient housekeeping, research and development, functioning of public organizations, and enforcement of the law.

* The ESEAs arrange for visits to universities and industries by *energy teams*.

* The ESEAs arrange for workshops for experts.

* The ESEAs facilitate relevant interaction and communication between *energy actors*.

5. Technological development by southern ESEAs

* The ESEAs stimulate small-scale energy technology experiments, and build on successful examples.

* The ESEAs arrange for private international cooperation in the field of environmentally sustainable energy technology which supports human resource development.

* The ESEAs invite for, screen and design project proposals for cooperation in the field of environmentally sustainable energy technology and submit these to donor agencies, or arrange for technology cooperation through joint implementation.

* Because opportunities for soft loans are limited, the ESEAs seek other ways to trigger commercial investments in the field of environmentally sustainable energy technology.

* The ESEAs contribute to the national reporting of emission inventories.

6. Expected benefits

* The private, public and NGO actors, the Global Environmental Facility and foreign donors join hands in building the foundation for environmentally sustainable energy technology development in the South

* This human resource building generates the domestic design and funding of environmentally sustainable energy projects.

* The long term approach of human resource development for environmentally sustainable energy technology in the South contributes to structurally tackling the long term problem of climate change

* The emphasis on energy efficiency and renewables presents an opportunity for *win-win* strategies, aiming at both economic and environmental benefits

* The human resource building for environmentally sustainable energy technology in the South contributes to technological and economic self-reliance of developing countries and preclude the establishment of new *white elephants*.

* Energy technology projects funded by multilateral and bilateral development agencies, the private sector and under joint implementation arrangements are more in line with the development of human capabilities needs in the South.

* Energy technology projects funded by multilateral and bilateral development agencies, the private sector and under joint implementation arrangements are more environmentally sustainable.

* The cost-effectiveness of technology transfers more assured.

* The donor-driven character of energy technology transfer is reduced.

* Special programmes are developed to enable multilateral development banks (MDBs) and commercial banks to spend at least 10% of their energy loans on environmentally sustainable energy projects.

* The discussion on the Global Environmental Facility's objective of incremental costs is reduced.

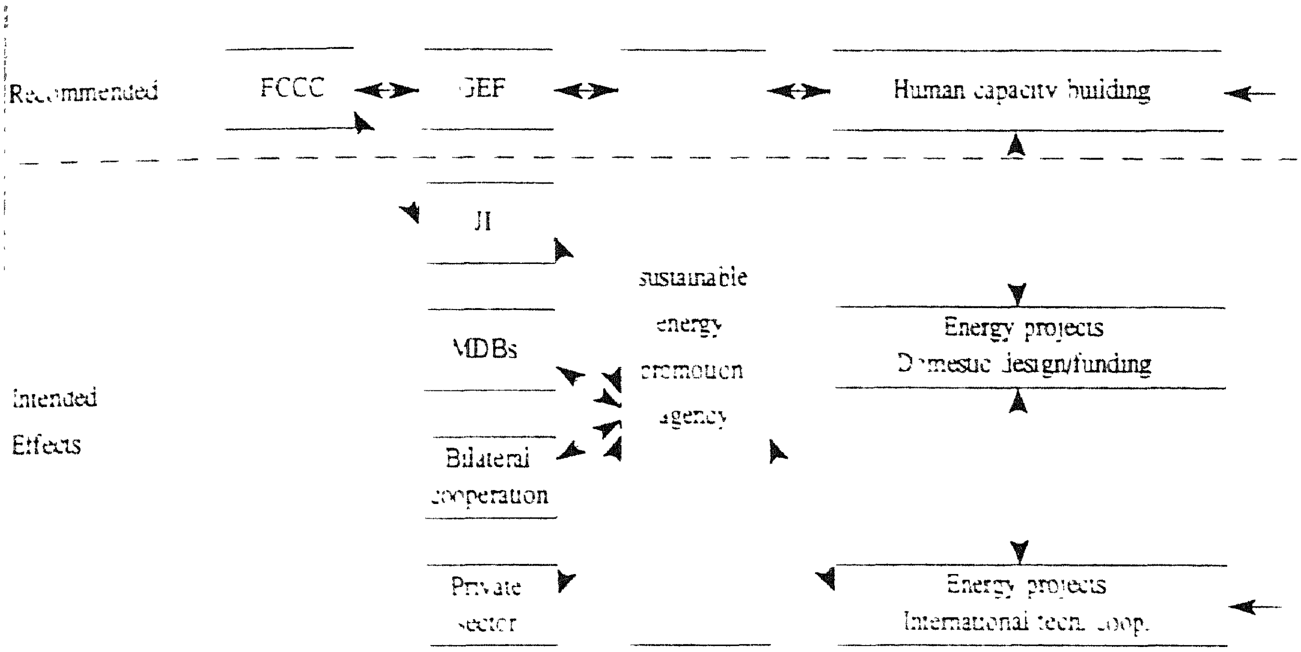

Figure   The position of sustainable energy promotion agencies

APPENDICES

A.1 Definitions

Technology

The term *technology* adopted in this report contains two aspects:

- Knowledge of methods and techniques of the production of goods and services, including skills for the application of these techniques. This knowledge is also called *software*, or *disembodied technology*.
- Tools, machinery, equipment and entire production systems. These are also called *capital goods*, *hardware*, or *embodied technology*.

Packaged and unpackaged technology

Packaged technology includes both software and hardware, or disembodied and embodied components. Unpackaged technology consists of only one component of technology, either software or hardware

Sustainable energy technology

This report distinguishes two types of sustainable energy technologies. The first are fossil fuel-based energy technologies that reduce the CO2 emissions per unit output (ratio CO2/y). Both improved hardware and better management can contribute. The second type of sustainable energy technologies regards renewable, non-carbon energy sources and their further innovation, diffusion and application.

Technology transfer

Technology transfer takes place when software or hardware or both are moved from one location to another (cf Rath 1993:28).

A.2 International Technology Transfer

Appendix A.2 is based on a review of relevant literature and expertise available at the Institute for Environmental Studies. First, it evaluates interactions between imported technologies and domestic systems. Second, it provides factual information about the most important channels of North-South transfer of technology. Third, it reviews various constraints to imports of desired sustainable energy technologies. The most prominent constraints identified are high financial costs for private purchasers, lack of foreign currency, insufficient availability of sustainable energy technologies, information, and risks in domestic contracting.

A.2.1 The position of transfer

Transfers of technology may insufficiently contribute to the development of domestic technical and institutional capacities in southern societies. Too often the transfers regard only *hard* or *embodied* elements, or technology packages without enough *soft* or *disembodied* elements. Furthermore, even the transfers of software technology have limitations.

Locally shaped technical skills and experience need a reorientation in order to deal with technological factors transferred from the North in recent times. Such a reorientation facilitates ways to select, acquire, absorb, operate, adapt, maintain and further develop imported technology to the benefit of the environment and economy welfare. Roots of adjustment problems lie in local knowledge, customs, perceptions and organizational principles, in short, cultural and behavioral structures which were once more or less functional. Processes of technology transfer are *appropriate* if they support reducing these problems.

Constraints to absorb and adapt imported technologies by management and labour are found in access to information, capital budget, economic risk and attitudes and support from governments. There occur inconsistencies between capital intensity, factor proportions or input requirements of the technology, and the resource and skill endowments of a country. Many imported technologies fail to fit in with the capital-labour mix. The developing countries typically lack in capital but have considerable labour resources at their disposal.

Three types of influences to decisions by energy actors are commonly discussed. First, prices of technologies are regarded as of central importance. Second, experienced uncertainties in the economic system, and information and availability of technologies are regarded as relevant. Third, the mutual proportions and interactions of these factors shift among various types of actors and stages of development.

A.2.2 Commercial channels of transfer

Much transfer of energy technology takes place through the commercial channels of trade and foreign direct investment. For private purchasers, the most important factor determining decisions is the cost-benefit ratio. Private purchasers prefer carbon intensive technologies to low carbon options as long as costs-benefit ratios of the latter remain

relatively unfavourable. These private decisions seldom reflect national environmental costs. Compensating government interventions may remain absent.

Trade

The trade channel concerns dealings between two parties. Here a supplier sells the technology once and the recipient acquires a legal interest in it. Technology transfer through trade typically applies to hardware, also called embodied technology. The price of the technology reflects the size of the benefit that accrue to both parties.

Suppliers consider technology invariably as a productive asset with a commercial value which should be reflected in its price. The larger the number of suppliers of a particular sustainable energy technology, the more the price will be market-based rather than depending on individual bargaining.

Purchasers of technology face several disadvantages. There may be insufficient information about the nature of a certain technology, prices and alternatives available. Insufficient information before a purchase may give rise to difficulties in managing the technology once installed. Moreover, there may occur monopolistic tendencies. As Rath et al (1993:31) write: 'Technology suppliers have thus been able to combine ownership of technology, dominant market power, access to financial resources, and skilled personnel to extract advantageous agreements from developing country firms and governments.'

Foreign direct investment

Under foreign direct investment, a multinational corporation may establish a foreign affiliate under effective control by the parent firm. Through foreign direct investment, technology is usually provided in a package of software and hardware, in return for equity, royalties and other explicit payments, or implicit payments such as profits for the parent firm.

Foreign direct investment is influenced by country credit ratings, which are themselves determined by the existing status of a country's balance of payments (UNCTAD 1994:5). The balance of payments reflects, *inter alia*, the role of other financial flows, including the debt service Large financial outflows required to meet debt obligations are common phenomena in developing countries.

In contrast to a limited number of fast growing Asian countries, most developing countries have difficulties in attracting foreign direct investment and thereby acquiring technology and capital. The capacity of countries to attract foreign direct investment depends, *inter alia*, on their political, economic and technical climate, which should be suitable and predictably stable for a long term investment (ECOSOC 1994:11).

Special arrangements

A technology may be sold under a *licensing agreement*, a legal contract under which the licensor confers certain rights upon the licensee for a specific duration in return for certain payments. Such transfers typically apply to software technologies. Payments may

take place in the form of royalties or a share in the profit, and typically depend on the bargaining process rather than on the nature or current market value of the technology.

Joint venture arrangements refer to partnerships between private or public enterprises where equity, risk, control and authority are shared. Technologies transferred through joint ventures typically consist of packages.

Turn key arrangements involve the embodiment of a fully packaged technology transfer, whereby the contractor hands over to the client a fully commissioned and operational plant, including all hardware and software components.

A.2.3 Non-commercial channels

Non-commercial transfers of technologies occur in two ways. First, technology can be transferred through official development assistance (ODA), non-governmental organizations, and international compensation mechanisms of environmental agreements. Assistance takes place in various stages of the technology transfer process, such as providing financial and technical assistance, increasing information on the technologies available, assisting in the assessment of national needs, or supporting the application and adjustment to local circumstances of an imported technology.

The second way to acquire technologies on a non-commercial basis is to make use of those technologies that have passed into the public domain. Examples include technologies that have never been transferred under patent restrictions, or of which the patent has expired, typically after 15-20 years.

In technology transfer via the non-commercial channel there is a high risk that the supply does not match with priorities of developing countries. A number of biases in transferring technology through aid have been identified. Touche Ross (1991) points at a flow of funds into large capital intensive projects, and imports of northern technology disruptive to indigenous technology innovation and diffusion.

Emphasis on transferring hard technology rather than soft technology, and tied assistance in lending arrangements can be added to this list. As a result, technology transfers through non-commercial channels are not always in the best interest of the receiving country. Moreover, official aid flows are stagnating, and it is difficult to trace the substantial new and additional resources that the industrialised countries have promised to provide in the context of the FCCC.

A.2.4 Constraints

The above provided information is reorganized and supplemented under the headings of various constraints reviewed below.

Financial constraints

International access to sustainable energy technology depends on the terms upon which a technology is purchased from commercial suppliers, and the terms upon which financing is made available to developing countries (Rath et al 1993:42). Hence, access to technology in the commercial channel is primarily a matter of finance. As stated above,

obstacles in the non-commercial sector are found in the quality of information and dissemination.

A major financial constraint operate at the national level. Many developing countries are severely limited in their ability to acquire technology for financial reasons. Developing countries face a lack of foreign exchange, and hence, the opportunity costs of capital may be extremely high. Most multilateral development banks and international lending institutions are technologically risk-averse (ECOSOC 1994:16).

As a result, governments may be reluctant to invest in projects that entail high capital costs. As foreign exchange in developing countries is often under government control, private enterprises may be severely limited in operating independently and purchase the technology they perceive needed.

Another important financial constraint are unfavourable cost-benefit ratios for the supplier and even more so for the purchaser of an energy technology. The buyer will compare the cost-benefit ratio for the sustainable technology in question with the cost-benefit ratio of alternative technologies. A sustainable technology will be selected only if the expected net benefits of this investment exceed the net benefits of a carbon intensive technology. Both explicit costs such as royalties and transaction costs, and implicit costs such as restrictive conditions are to be considered. Capital is often lacking in cases where the technology demands a major upfront investment. Even though a number of sustainable investments may be economically justified over time, purchasers prefer carbon intensive technologies with lower upfront investment, disregarding the fact that these are less profitable over time.

Consultancy and service contracts have to be bought from industrialized countries as complete systems. This reinforces the prolonged dependency. In many cases, developing countries do not purchase individual components of packages separately, even if resources are available domestically.

Multinationals, in order to maintain control over their technologies, may impose tight control over product choice and production methods, leaving the local subsidiaries with very limited control over technologies. Similarly, turn key arrangement often bring very little real transfer of skills or development of local technological capacities.

Research indicates a number of restrictive clauses in case studies on technology cooperation between multinationals and Asean countries (cf Horino & Siy 1986:45). These restrictions include limitations on marketing territories, purchasing and pricing strategies, diffusion of technology, and local research and development. Expenditures for tied purchases of materials from technology suppliers constitute a large proportion of total costs of technology transfer.

The instability of commodity prices and ineffective stabilisation programmes contribute to the stagnating and unstable macro-economic climate in many developing countries. Credit facilities and foreign and domestic investments, in particular to overcome the international debt problem are insufficient.

Technology transfer aid programmes often fall short in perceiving southern interests and reinforcing southern capacity building. The environmental technology programme MILIEV of the Dutch government is criticized for such an approach. It is regarded to be northern-industry-driven instead of aiming at an integrated development in the recipient countries.

Information constraints

A very important barrier for the would-be purchaser of a technology is the lack of information about a number of issues. The purchaser may lack information about the range of technologies available and the expertise to apply them effectively. He may not know about the range of suppliers offering the technology and the performance of these technologies.

Knowledge of the market price, including an implicit and explicit cost-benefit picture may be inadequate. Which programmes to finance technology transfer are available? What are the environmental effects of technologies and the win-win targets of both environmental and economic benefits over time? The purchaser may not be aware of the beneficial effects of the investment during the entire life cycle of the technology.

On the supply side, information may be lacking with respect to the potential of the markets, and the range of potential buyers. The purchasers, in turn, do not sufficiently shop around for technologies which they perceive as needed. The key is to streamline national and international communication and information networks and organizations, including NGOs.

It has been argued that the key constraint is not a lack of information, but rather a lack of mechanisms and incentives for dissemination of information, in particular to small enterprises. Also the access problem in the non-commercial sector can mainly be solved through improvement of information systems (ECOSOC 1994:9).

Although there are many institutions and mechanisms that aim at spreading information, a number of constraints do operate. First, the relevant organizations often lack in coherence. Second, they tend to have a specialized clientele, for instance located within single ministries or departments. Third, they tend to regard dissemination as instrumental to particularistic purposes, which precludes potential users from knowing that the information is available.

Institutional constraints

Institutional constraints include weaknesses in linkages between government and industry, the ability to integrate new technologies with existing procedures, intellectual property regimes, national research and development institutions. There may be a lack of banking and insurance facilities. Small and medium enterprises that can diffuse energy technology on a commercial basis may be absent.

Southern governments insufficiently facilitate the transfer of sustainable technologies, in particular by failing to strengthen infrastructural provisions and reliability in economic life. These governments normally differ from northern governments which came to guarantee the enforcement of economic contracts. Southern economic systems have much artificially created delays and shortages in the supply of energy, raw materials and products, timely purchase, efficient public transport, construction work labour, and payments. In such economic systems purchasers are risk averse and prefer short-term investment. Consequently, they operate with widely applied and tested technologies.

Intellectual property rights

The controversy between industrialized and developing countries about access to technology protected by patents is subject to much discussion. Innovators of technology want to protect the value of their intellectual property and preserve incentives to innovate. Developing countries attempt to reduce excessive restrictions imposed by prevailing patent systems to acquire access to new technologies, including sustainable energy technologies.

A legitimate question arises about to what extent the access to sustainable energy technologies is protected by property rights. A large body of useful sustainable energy technologies have already entered the public domain and are unaffected by international patent systems. Furthermore, most proprietary sustainable energy technology is available through commercial channels.

Touche Ross has found that patent protection and the costs of access to existing technologies may only constitute a problem in the case of transfer of very new *high-tech* facilities. However, it is also found that sustainable energy technologies, particularly software components, are often available at low costs, and formal barriers to access such as patents are no significant obstacles to successful transfer (1991:26-47). Other studies support these observations (cf Almeida 1993:33, OECD 1992).

Based on the study of a number of cases, an OECD report concludes that the majority of technologies fundamental to limiting greenhouse gas emissions are not highly sophisticated hardware, but involve shifts to 'clean processes'. These imply a more carefully management of resources in the input stage and during the production rather than controlling the output of emission. Such technologies and know-how are not subject to patent protection and defy the exclusivity of the patent structure (OECD 1990:12-13).

Choucri (1994) concludes that 'while the issue of intellectual property rights is undoubtedly salient, it is only one among the critical factors that need attention. Excessive focus on the patent issue may distract from the action that can and must be taken now to encourage innovation and creativity in all countries.'

Constraints to research and development

The key to enhance technology transfer is to strengthen local research and development (R&D). Insecurities in the economic system operate to discourage long term investments, including for R&D. Nonmechanistic thinking implies a concentration on societal problems and solutions to gain benefits, rather than on technological problems and solutions to gain economic or environmental benefits. Hence, nonmechanistic thinking also precludes efforts to innovate and diffuse sustainable energy technologies.

Transfers of technology often prove inadequate to change economic risk and nonmechanistic thinking to facilitate local R&D. Moreover, suppliers of technology have vested interests which preclude to local R&D. In particular if multinationals are the only source of technical information and assistance, there is a potential danger of dependency.

Multinationals prefer to avoid duplication of research efforts, overcome the shortage of skilled manpower and technical infrastructure in developing countries, exploit economies of scale, and therefore concentrate R&D in their home country. As a result, technologies

transferred to developing countries remain not only poorly attuned to local circumstances but also preclude local R&D for sustainable energy production and consumption.

Regulations

A proper environmental regulation in both the supplying and the importing country largely contributes to the transfer of sustainable technologies. In the supplying country, a solid environmental regulation creates incentives to develop sustainable energy technologies. In developing countries, environmental regulation is the major determinant to create effective demand for such technologies.

However, environmental policies and legislation in developing countries are generally much less stringent than in the industrialized countries, and actual enforcement is a critical problem. Due to the lack of environmental regulations, importers continue using technologies that do not take into account environmental interests, since they are more easily available and their use already familiar to producers (Almeida 1993:31).

Multinationals seeking to establish a new project lack the regulatory incentive to provide sustainable energy technologies, and may even base investment decisions, including the choice of country, on the weakness of environmental regulation.

An accumulation of concerns of southern governments about their international position have led to public control of access to technology by the private sector. These concerns are about excessive cost of technology transactions in contrast with a lack of foreign currency, growing dependency, incompatibility with national interests, limited domestic institutional capabilities to absorb technologies, and ability of private and government actors to negotiate informed contracts with foreign suppliers. Interventions include foreign exchange control, outlaw practices deemed to violate national interest, tariffs on imported equipment, and limitation of foreign equity and participation.

Finally, policies in developing countries typically lack coordination between development and environmental strategies. Furthermore, there is a danger that technology regulations reflects tastes of luxury oriented elites without heeding the broader social concern of the rest of the country (Haas 1992:22).

A.3 Cogeneration in the Indian sugar industry

A.3.1 Introduction

Sugarcane cultivation

Sugarcane cultivation in India is concentrated in the states of Uttar Pradesh, Bihar, Punjab, Haryana, Andhra Pradesh, Tamil Nadu, Karnataka, Gujarat and Maharashtra. These nine states account for nearly 95% of all sugarcane production in the country. About 60% of the cane produced is refined into sugar, while the remaining 40% is used in the small scale industry to make gur and khandsari[3].

Sugar production

The annual sugar production touched a figure of 13.4 million tonnes in 1991-1992, but fell to 10.6 million tonnes in 1992-1993. With these figures, India is the largest producer of sugar in the world and its sugar industry is the second largest agro-based industry in the country after textiles, with an annual turnover of Rs. 55 billion. It is projected that the production would increase to nearly 14.1 million tonnes by the end of the Eighth Plan (1996-1997) which would be sufficient to meet the domestic demand.

With the growth of population and levels of income, the demand for sugar is rising. However, the per capita sugar consumption in India was only 12.5 kgs in 1990-1991 against a figure of 30-50 kgs by international standards. On the other hand, the change in life-style is exemplified by the decrease in per capita consumption of traditional sugar products. During 1988-1989, per capita consumption of gur was 11.5 kgs and sugar 12.1 kgs, but two years later in 1990-1991, this consumption changed to 10 kgs of gur and 12.5 kgs of sugar. Presently, roughly 46% of the cane crop goes to gur and khandsari units, against 50% in 1977-1978. This ratio is likely to move further in favour of sugar units.

To provide a historical perspective, at the time of independence in 1947 there were about 150 sugar mills mostly located in Northern India. At present there are nearly 450 sugar mills in operation, out of which a substantial number in the south Indian states of Andhra Pradesh, Tamil Nadu and Karnataka.

India exports small quantities of sugar (0.1-0.5 MTPA) after meeting its domestic demand. Occasionally it resorts to importing sugar when the cane production goes down due unfavourable weather conditions. In the season of 1993-1994 the country had to import sugar to meet the domestic demand.

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[3] Gur and khandsari are traditional forms of sugar produced through an open pan process at atmospheric pressure, through traditional methods. The extraction process is highly inefficient and a portion of the sugar in the cane remains unrecovered.

Sugar industry

Ownership of sugar mills in India is either private, public, or by cooperatives. Of the 448 licensed sugar mills in the country, 128 are in the private sector, 62 in the public sector, and 258 in cooperative sector. The cooperative sector accounts for more than 50% of the sugar production in the country. Sugar cooperatives, owned largely by small planters, are organized in state federations, which, in turn, are coordinated by the National Federation of Cooperative Sugar Factories (NFCSF). The NFCSF represents the interests of its members at the national level and ascertains the provision of technical assistance to sugar cooperatives. Other sugar mills are grouped in the Indian Sugar Mills Association (ISMA), which aims at furthering the interest of its members at the government level.

Cogeneration technology

Bagasse-based cogeneration offers numerous advantages to the firms at the micro-level, to the country and the world environment. It offers the potential of helping to meet the growing power demand in the country without generating any additional greenhouse gases.

Strictly speaking, the concept of cogeneration of power and steam to meet the internal needs of the plant is inherent in the sugar processing itself. Cogeneration means concurrent production of electricity and process heat in a single integrated utility system. The location of the sugar mills in rural areas far flung from the power grid, the availability of the by-product fuel bagasse, and the process steam requirement at lower pressures - all led to the adoption of cogeneration in the industry, be it in a limited way.

By generating captive power, the mills were able to insulate themselves from the vagaries of the State Electricity Boards (SEBs). Moreover, the bagasse-based power proved to be much cheaper than what sugar mill owners paid to SEBs.

However, almost no Indian sugar mill has pursued the proper tapping of the vast cogeneration potential existing in the factories so far. Cogeneration for the sugar mill should actually mean making optimum use of steam generated from boilers. This involves the production of maximum power out of the steam before it is supplied to the system for process heat requirements. The surplus power generated can be supplied to ancillary units, neighbouring factories or the grid.

The sugar industry lacks the institutional support it hoped for in setting up advanced cogeneration systems. There is no clear cut government policy in place for the buy-back arrangement of excess power which can be produced by the sugar mills. The technology required to generate power for export to the grid demands the installation of high pressure multi-fuel boilers and turbines which are not readily available indigenously to the sugar industry.

A.3.2 Indian sugar mills

Production capacity

The Indian sugar industry is a typical mix of relatively small size, old plants existing and newer plants with larger capacities. With the increasing demand of sugar over the years, the small, old mills have been increasing their capacities in stages. In the process, they added small sized boilers and turbo generator sets in their plants. These could just meet the enhanced requirements of thermal and electrical energy in preference to the setting up of high pressure cogeneration systems which require huge capital investments.

The situation for mills newly coming up in the country is somewhat different. The minimum economically viable size of the plant which can be set up nowadays is of 2500 tonnes of cane per day (TCD). The central government encourages entrepreneurs to expand their plant capacities to 5000 TCD and beyond. As a result, plants with capacities far more than 2500 TCD are seen in the Indian sugar industry. However, even now, the average size of an Indian plant is 2100 TCD. By international standards this is a small size. The average size in Australia is 8268 TCD, in Brazil 8296 TCD, and in Cuba 4037 TCD.

Power and bagasse

Generally, a sugar mill in India is self-reliant in power and bagasse. However, some sugar mills produce small quantities of surplus bagasse while others are deficient by a small quantity. These different outcomes depend on fibre content in the cane, quantity of juice, type of clarification process and evaporation effects, and steam driven or electric driven prime movers. Therefore, some sugar mills can produce a little surplus power while others are deficient in power by a small margin during the season.

A typical sugar mill in India produces 30% wet bagasse based on cane crushed which has a moisture content of around 50%. This bagasse is mainly consumed in small bagasse fired steam turbine systems supplying steam at 15-25 kg/cm^2 which is just enough to meet the on-site steam and electricity needs of the plant. A 2500 TCD mill normally produces 64 TPH steam at 22 kg/cm^2 and 330°C. This is used partly in drives for the mills and balance for generating approximately 2.5 MW power through a back pressure turbo generator set for captive use. The process steam requirement is normally in the range of 500-550 kg of steam per tonne of cane crushed.

Turbines and boilers

From the view point of energy efficiency this type of a sugar plant is somewhat inefficient, consuming all the available bagasse so that it does not accumulate while just meeting the electric and steam needs of the plant. The boilers normally have efficiency levels of the order of 60%. The back pressure turbines (1-3 MW range) normally consume 10-12 kg of steam/Kwh. As a comparison, in advanced countries boilers operating at efficiency levels of more than 70% and steam rates of 7-9 kg/Kwh are common.

The sugar industry is basically a seasonal industry with the sugar season lasting for nearly six months in a year. The all-India average was 172 days for the season 1991-1992. The boilers are designed to use only one fuel. Bagasse is available as a by-product in the crushing season. If these mills have to be operated in the cogenerating mode, it would be worthwhile to run the plant in the off-season also with fuels such as coal, lignite or other biomass fuels, depending upon the location of mills and hence the need to install multi-fuel high pressure boilers.

A few indigenous manufacturers claim to have developed the capability to manufacture fluidized bed boilers operating at 63 kg/cm^2 pressure with bagasse as the primary fuel. So far, no such boilers have yet been supplied to any of the sugar mills. Thus, it can be said that the capacity for indigenously manufacturing boilers which can generate steam at pressures of 63 kg/cm^2 or 84 kg/cm^2 are limited.

Most of the existing turbines used in the industry are of the back-pressure type exhausting steam at around 1 kg/cm^2. These turbines have been supplied mainly by indigenous manufacturers and conform to specifications as laid down by the National Federation of Cooperative Sugar Factories Limited.

For generating 10 MW or more of power and to ensure effective utilisation of the cogeneration system in the off-season, it is essential to resort to schemes with energy efficient double extraction condensing turbines with controlled parameters and accessories. This elimination of pressure reducing valve stations faciliates high efficiency of power generation.

Indigenous manufacturers of these turbines claim to have the capability to produce multiple extraction condensing turbines rated at 65 kg/cm^2 or more. In practice, however, most of the small turbine manufacturers do not make multiple extraction turbines. This is mainly due to the fact that in the lower range of capacity, no market is perceived for multiple extraction turbines. Therefore, a cogeneration scheme to be installed at a plant needs to be designed specific to the plant depending upon the age of the plant and operating conditions.

Power supply in India

A few studies have estimated the potential of surplus power generation from the Indian sugar plants. The potential will depend on the degree of efficiency improvements adopted by the mill as well as the boiler and turbo-generator configurations implemented.

The Task Force set up by Ministry of Non Conventional Sources in 1993 estimated the potential of surplus power generation as 3436 MW by the end of the Eighth Plan (1996-1997). The estatimation of this potential was based on the assumption that TCD plants 2500 MW in the country number 358 in 1996-1997, adopt steam parameters of 65 kg/cm^2 and $480^{\circ}C$, and generate power through extraction cum condensing route with no surplus bagasse.

It is reasonable to assume that in the absence of any initiative to generate power from biomass based cogeneration, this power is generated from coal-based thermal power plants. After all, nearly 70% of the present day power generation is from thermal power plants. A number of new plants are planned to use coal or gas as the primary fuel. Taking only the CO_2 emissions from conversion of coal to electricity results in savings of

approximately 1.24 kg CO_2/Kwh. This omits accounting for the GHG emissions from coal mining, processing and transport and emissions from other second order sources. Based on a cogeneration potential of 3436 MW, these cogeneration plants in their 25 years lifetime will save about 500 million tonnes of CO_2 emissions.

A.3.3 Constraints for technology transfer

Although the Indian sugar industry has been practising cogeneration in a limited way to meet its captive energy needs, commercial cogeneration has not really taken off. The various impediments to the adoption of the technologically advanced cogeneration schemes in the sugar industry are highlighted below.

Technology

Technological constraints the installation of a commercial cogeneration project relate to determining the cogeneration potential, the detailed system engineering, selection and procurement of the plant, and equipment and operation of the cogeneration plant. The determination of the cogeneration potential in the sugar plant is a fairly straight forward process and the Indian sugar industry personnel and engineering consultancy firms are fairly competent to handle this aspect. Similarly, the detailed system engineering for installing the plants can be done indigenously.

As mentioned earlier, it is with regard to the availability of high pressure energy efficient boilers and turbines for the cogeneration plants that the indigenous capabilities are limited. Regarding the installation and commissioning of the cogeneration plant, the Indian sugar mills also encounter a typical problem which is connected with their being old and obsolete. Partial modification of their plants will not be justified. Since a large number of sugar mills have expanded in stages, the lay-outs sometimes have become very complex. Any cogeneration project envisaged in such plants would require a comprehensive study of the existing plant and machinery and plant lay-out so that it justifies the large investments required.for cogeneration facilities.

A related problem pertains to the synchronisation of the cogenerator with the grid. These include safety, power quality, reliability, protection of transmission and distribution facilities, grid interfacing and dispatching problems. The utilities must maintain the integrity of their systems in order to ensure a reliable supply of electricity to their customers. Therefore, any interconnected cogeneration system must include equipment dedicated to protecting both the utility and cogenerator from problems that may originate from the grid or the cogeneration system.

There may also be problems of grid synchronization when the electricity cogenerated is at 11 KV while the grid needs to be fed in at 33-66 KV. In order to protect the cogenerator as well as the interconnecting distribution system, it will be essential to provide for suitable over and under frequency protectors and over and under voltage and current protection devices.

Human endowed capability

Sugar industry, presently employs low pressure and low temperature systems for steam and power generation. High pressure and high temperature cycles for cogeneration plant would require expert professionals to operate and manage the systems. Appropriate training for the professionals to operate the cogeneration systems efficiently forms an important element of technology transfer of high efficiency cogen systems.

Apart from these above mentioned technical issues pertaining directly to the cogeneration plants, other energy conservation schemes which can be adopted by the sugar mills are equally relevant in order to increase the cogeneration potential from the sugar mills. The improvement by way of economising steam consumption in the plant would result in availability of surplus energy in the form of electricity and bagasse. This helps the plant in optimising its energy consumption. Thus, in order to derive the maximum advantages from the transfer of advanced cogeneration technology, transfer of know-how which results in reducing the process steam requirements in the sugar manufacturing process, is equally important.

Firm level constraints

Investments required for setting up cogeneration plants are substantial, sometimes even more than the capital required to set up a new sugar mill. Given the scarcity of capital in India coupled with the increasing demand of sugar, the mills tend to select their investments based on financial rates of return of competing investment options.

However, with the opening up of the Indian economy and a number of liberalisation measures initiated by the government of India in the last two years, it can be expected that financial resources from foreign partners would be forthcoming. However, this is provided the regulatory and policy framework is favourable for installing cogeneration systems in the sugar mills. In fact, one cooperative sugar mill in Maharashtra has just signed an agreement with a US based company for putting up a cogeneration plant with financial assistance from the US Department of Energy. Similarly, a few other mills in Uttar Pradesh and Tamil Nadu are in an advanced stages of finalising agreements. The US based companies will provide financial and technical support for execution high pressure cogen systems in their plants.

Uncertainties

The inherent problem of risks and uncertainties associated with cogeneration for power export also detered direct investments by the industry. Since the demand for sugar in the country has been increasing over the years, the sugar mill owners have preferred to increase their production capacities rather than venturing into a relatively new field of power generation which has traditionally not been their line of business. Nowadays, with the state governments and commercial banks providing back up guarantees for payments, the risks associated with non-payment of dues by the SEBs has been tackled to a certain extent.

Another area of risk for the sugar mills is the possibility of non-availability of off-season fuel. There may be inadequate quantities of rice husk, field trash or other biomass fuels. The rates of return on the investment are highly sensitive to the plant load factors at which the cogen plants are operated.

The risk is higher for plants for which utilisating commercial fuels is not economically attractive. Plants in Tamil Nadu can use lignite which is available locally. For plants in Punjab, lignite or coal usage would be an economically non-viable proposition. Even the price of bagasse, which is a captive fuel, can vary considerably over time. This is due to the diversion of bagasse for other applications. Bagasse is an excellent raw material for paper manufacture. These grey areas need to be tackled at the inception stage for any potential sugar mill owner venturing into this field.

State Electricity Boards

As mentioned earlier, SEBs have to play a very important role in promoting the cogeneration schemes in the sugar industry. What counts are tariff rates for buy back of power, the provision of wheeling and banking of power, and the consequently working out power purchase agreements attractive for potential cogenerators. The SEBs assume even greater significance if the fact is considered that a large proportion of the investment may come from foreign direct investment. These foreign investors would require firm commitments in terms of their returns on the capital invested.

A clear legal framework is a prerequisite for ensuring adoption of commercial cogeneration. Recently, the Enrol company requested counter guarantee agreements from the central government to set up a large private sector power project to be set up at Dabhol in Maharashtra. A uniform policy of having long term power purchase agreements at remunerative prices between the SEBs and the cogenerators would encourage sugar mill owners to put cogeneration facilities.

Apart from the role of SEBs, there does not exist any centralised national agency in the sector which can provide easy access to scientific and detailed information. Nevertheless, information is required on the different types of cogen systems available around the world from various manufacturers of boilers and turbines. There is also a scarcity of information on the performance characteristics of operating cogen systems in other countries. As a result, there is a reluctance on the part of potential cogenerators to adopt the technology.

In such an environment, providing legal support, information, spares, and technical manpower after the technology is implemented constitutes a major part of the institutional development process. The mechanism of aid can play a very important part in this exercise.

Until recently, one of the main reasons which was often given for the cogeneration not taking off in the Indian industry was the unwillingness on the part of the SEBs to purchase the electricity from the sugar mills. From a particular utilities point of view, the power produced by the cogenerator for feeding to the grid is, of course, of insignificant magnitude as compared to the operation of the grid. However, the combined effect of these small power producers can add up to a significantly large generation capacity for the nation. Absence of any policies which encourage the sugar mills to cogenerate had

really been one of the most crucial factors in inhibiting commercial cogeneration in the Indian sugar industry. The US example of PURPA is worth mentioning here because it was this Act which made it mandatory for the US utilities to buy power from the cogenerators at 'avoided costs'. Avoided cost is the added cost to the electric utility that the utility will either generate itself or purchase elsewhere if it did not purchase from the cogenerator. But now, some of the SEBs have come out with impressive schemes to encourage commercial cogeneration which offer attractive buy back rates and also allow wheeling, banking and third party sales. In fact, one of the SEBs has offered to even participate in the equity capital of the sugar mills opting for installation of cogen packages in their plants. It was solely the positive attitude of the Tamil Nadu State Electricity Board (TNSEB) which has prompted a few sugar mills in Tamil Nadu to put up cogen plants in their factories. It is, therefore, important that the utilities must consider cogeneration option as a source of firm power supply and should consider the environmental and social costs of conventional power viz-a-viz the cogenerated power while carrying out their long term planning exercise. Pricing policies must be seen to be reflective of economic long run marginal costs of power production and to be guaranteed from fluctuations due to political and other non economic considerations. Due the recent changes in the Government policies towards cogenerators, it seems that biomass based cogeneration in sugar mills is ready to take off in a big way.

Government initiatives

In direct contrast to these constraining factors, the Ministry of Non-conventional Energy Sources, Government of India plays a stimulating role in promoting biomass based cogeneration in the sugar industry. It constituted a Task Force on Biomass Cogeneration in 1993 to assess the biomass based cogeneration potential in the country and suggest means to tap this potential. As mentioned earlier, this Task Force estimated the potential of surplus power generation as 3436 MW by the end of the Eighth Plan (1996-97).

The Ministry of Non-conventional Energy Sources has recently launched a National Programme on Biomass based Cogeneration to encourage the sugar industry to go in for cogeneration projects. Under this programme, the government of India gives financial incentives for 1) demonstration cogeneration projects in sugar mills and 2) preparation of detailed project reports for bagasse based cogeneration. A maximum of two demonstration projects is sanctioned in each of the major sugar producing states. The condition is that surplus power generated from cogenerators is supplied to the SEBs or to other bulk electricity consumer.

Similarly, the Ministry of Power has introduced the two-power tariff system to encourage private sector participation in power generation which would guarantee returns to the private investors. The first part of the tariff ensures recovery of fixed costs including returns. This is based on performance at normative parameters. The second part of the tariff ensures meeting of variable expenses, based on units of electricity actually supplied.

Incentives will be provided for the achievement of efficiency levels, higher than the normative parameters. Once the rate for sale of power is fixed, no limits of any sort will be put on actual profits earned by a generating company. The system also provides for

the signing of a contractual agreement. This lays down rates for the bulk sale of power by a generating company to an SEB for a specified period.

In addition, an important source of funding for the Indian sugar industry has all along been the Sugar Development Fund (SDF). SDF is administered by the Sugar Directorate of the Ministry of Food and Civil Supplies, Government of India. It advocates that if a cogeneration scheme is an in-built process requirement or part of a modernisation programme, funds can be partly made available by the SDF. It is felt that these governments efforts are promising but the implementation of programmes leaves much to be desired.

A.3.4 Conclusions and recommendations

Despite potential benefits to the Indian economy and the proven success of the cogeneration technology in Hawaii, Cuba, Australia, or Reunion Island, commercial cogeneration selling surplus power to the grid is still to be realised in India. Of the various constraints discussed in the previous section, perhaps the largest impediment had been the lack of clear policies by the central and state governments regarding the sale of cogenerated power to the grid.

In turn, this reflects the SEBs' uncertainty about the reliability of cogenerated power and the impact of such schemes on the overall operation on the grid. Thus, it can be said that a concrete basis or policy framework is essential. It should ensure commitment by SEBs to purchase power from sugar mills at mutually acceptable rates.

The growth of cogeneration in the USA owes much to the public utilities buying back electricity from cogenerators at prices representing marginal production costs. The utilities also provide access to the transmission and distribution network at fair prices. Similarly, recent changes in the policies of some SEBs has prompted a few sugar mills to think in terms of taking concrete steps for establishing cogeneration plants.

To provide the economic impetus for adoption of cogeneration, considerable efforts on the part of SEBs and the government are required. They have to impress upon the potential cogenerators that the government's policies for purchase of power and banking would be encouraging.

Constraints such as *technological inertia*, especially for older mills, in adopting the advanced cogen options, of course, do exist. However, once the sugar mills managers become fully aware of the enormous advantages, their reluctance to undertake the plant modifications would be overcome

The high capital intensity of a cogeneration facility means that in a developing country such as India the prospective cogenerators find it difficult to provide the initial capital. Therefore, other investment promotion mechanisms like foreign direct investments, loans from foreign financial institutions at attractive rates, BOOT and the Global Environmental Facility and joint implementation can be reinforced.

Considering the kind of environment and constraints under which the Indian sugar industry operates, transfers of certain plant and machinery through foreign direct investments is preferred. The method of *unpackaged* technology acquisition is preferred because India has competent technical and managerial manpower. They have the capabilities to absorb the new technology through training at the works of foreign technology suppliers.

A.4 The BPL refrigerator company

A.4.1 The Indian refrigerator industry

Energy efficient technology as such is not on the agenda of refrigerator manufacturers in India. Energy efficiency and environment protection are no saleable concepts for Indian market or Indian public policy makers. Nevertheless, energy efficient technology is finding an indirect entry as part of modern, sophisticated technology and professional excellence in manufacturing and marketing.

The refrigerator industry in India dates back from the mid-sixties. At present, there are eight manufacturers of refrigerators. Four of them have captive facilities for the manufacture of compressors. Two other manufacturers exclusively manufacture compressors. They supply to the refrigerator industry as well as to producers of refrigerated cabinets, water coolers and room air conditioners.

Indigenous technology development in the field of compressor design and development is absent in India. All the compressor and refrigerator manufacturers have technology partnerships in one form or another with foreign companies.

Refrigerators range in capacities from 65 litre to 380 litres. The 165 litre unit had 90% of the market sales in 1990. The population of domestic refrigerators in India in 1991 was estimated to be about 8.3 million units. With rapid growth in the Indian economy and changing life styles of Indian middle class, the refrigerator is becoming to be perceived as a necessary household commodity rather than a luxury. The refrigerator market grew at a rate of 21% from 1986 to 1990. The projected annual demand growth till 1998 is 20% and from 1998 to 2005 is 15%.

About 1.4 million units of refrigerators were manufactured in 1991. The production capacity of this fast-expanding sector commissioned is 2.5 million units per annum now. The demand in refrigerator market is expected to stay at 20% per annum for several years. The demand for larger size refrigerators is expected to grow as well.

Considering these expansions, it is high time to introduce energy efficient refrigerators in the Indian market. Field and laboratory tests show that the average energy consumption of Indian refrigerators falls short of the international standards. There is lot of scope for technology upgrading in this sector. The state-of-the-art technology in the sector has the scope to reduce energy consumption ranging from 10% to 25%.

A.4.2 BPL Refrigeration Ltd

The BPL Refrigeration Ltd company has been selected here because it reflects a progressive organisational culture and manufactures refrigerators with technology completely purchased from SANYO in Japan. It is oriented towards accessing energy sound technologies and doing in-house development on them. Moreover, the BPL Refrigeration Group is the only refrigerator company in India to have used energy efficient compressors and refrigerating systems technology. The BPL compressors have the best energy efficiency ratio amongst all refrigerator manufacturers in the country.

TERI has a constructive relationship with the BPL Refrigeration company. Plant and machinery specifications, assistance in sourcing the same globally, detailed plant lay-out, detailed product specification with description of essential components designs, form and nature of materials to be used and the general process of assembly were provided. Additional information is from the *India Country Programme*, Government of India.

Technical capacities

The BPL Group is a completely private sector owned group with number of companies mostly manufacturing consumer goods in India. In addition, the BPL Engineering Ltd is in the process of establishing a compressor manufacturing plant in Hyderabad, South India in technical collaboration with SANYO, Japan. The production of energy efficient compressors in India is expected to start in 1995. The compressors will be manufactured for CFC-12 as well as HFC-134a as a refrigerant.

The current capacity of the plant is 400 refrigerators per day. An additional production line is expected to be operational in 1995 to increase the production to 1000 refrigerators per day. The expected production for 1994 is about 85,000 refrigerators. The refrigerator trial production was started in 1993.

Thanks to the applied refrigeration system technology, the refrigerators have better heat dissipation from condenser since the condenser tube is attached to the sides and rear of the cabinet body. Optimum utilization of cooling is by fan cooling of different compartments. Each compartment is maintained at the appropriate temperature by thermostats which regulate the amount of cold air allowed in.

More efficient heat transfer takes place through superior design of evaporator. The fan switches off when the door is open. There is a superior process technology and closer tolerance for better performance. BPL is the only refrigerator company in India at present that establishes an up-to-date R&D test laboratory for a compressor and refrigeration system in its two plants.

Marketing

BPL entered the refrigerator market with the most difficult product first: the four-door model for upper class consumers. It did not enter the 165-litres refrigerator market initially. This large market risk was met with by creating a superb product quality and thorough planning of marketing strategy and campaign.

The market planning consisted of four elements. The product was made available all over India. The product was introduced as a novelty in Indian market to attract consumers. The BPL refrigerator was made a status symbol and consumers and dealers were well informed about the international class features of BPL's product. Finally, technical qualities were made known as outstanding. The product was highly reliable and it was ensured that the failure rate of BPL's refrigerator is less than 0.6%. This was very important since sales of the frost-free model of Videocon had suffered considerably after failures in the initial stage.

Corporate culture

BPL's top management stresses quality, risk acceptance, openness and professionalism as basic values in the corporate philosophy to inspire the management and technical staff. The management has spiritedly accepted the challenge of introducing an international class refrigerator in Indian market. This venture brings quite a few problems and uncertainties, especially due to lack of local component base and unique design and marketing requirements of India. Nevertheless, BPL is quietly trying to revolutionize the Indian refrigerator scene. Simultaneously BPL is upgrading skills of local vendors through provision of technology and manufacturing inputs.

A spirit of transparency operates while sharing, discussing and solving any kind of or managerial of problem in the company. Professionalism is increased giving shape to creative solutions developed. The management tirelessly pursues professional excellence in the manufacture and marketing of the products.

A.4.3 Constraints for technology transfer

Information

Information about available technologies, either from SANYO or any other source, has never been a constraint for BPL. BPL keeps itself completely updated on all technological advances taking place in the refrigeration sector. The channels of information are through regular training of BPL's engineers at SANYO, attending international conferences, and reading technical journals and reports.

In general, it is needed to set up a national refrigeration research and development laboratory on the lines of Oak Ridge National Laboratory (ORNL), USA. Such a centre can generate technical information for Indian usage conditions and disseminate that to the industry. It would also be able to facilitate technology adaptation and absorption process to Indian conditions.

Restrictive clauses in transfer agreements

The technology transfer agreement of BPL with SANYO is quite flexible and considerable freedom is given to BPL for taking technical decisions according to business requirements of BPL in India. BPL is not tied to imports of all critical components from SANYO only. BPL is free to source its components locally to ensure market competitiveness. Adaptation to Indian conditions was done by BPL and SANYO. Day-to-day adaptations of production to optimise value for customer is done by BPL while keeping SANYO informed about it. Technological independence exists whereas BPL is assisted in setting up a comprehensive R&D facility for component evaluation. SANYO helps BPL to upgrade facilities in line with SANYO's own changeover to HFC134a.

The concerns of SANYO are that royalty is paid to them as per the agreement, and the product quality is not compromised at all. The major restriction under the agreement is the prohibition of technology transfer to third parties without prior approval of the SANYO.

Technical skills

Materials technology is underdeveloped in India. This acts as a major constraint in manufacturing perfectly finished material components for both compressors and refrigerators in India. There is a lack of local component base and unique design and marketing requirements of India. The reasons cited for this constraint were a lack of appropriate technical skills and a lack of professionalism in the concerned local industries.

The technology supplier SANYO was initially doubtful about the level of skills of Indian staff and local vendors. This doubt was reduced during the intitial months of interaction between engineers of SANYO and BPL preparing the erection and commissioning of the plant. The engineers from BPL were trained at SANYO's plants in Japan. SANYO has provided the services of its engineers for providing on site initial production supervision and technical problem solving at BPL's manufacturing facilities. Adaptation of compressor and system design to suit local operating conditions was done by BPL's staff in consultation with SANYO. No constraint was felt by BPL in this process.

Another leading refrigerator manufacturer, Videocon, obtained only product designs from Matsushita, Japan. Its frost free refrigerators failed in the field initially due to lack of understanding by Videocon on technical details of manufacturing in India.

Ancillary industries require modernisation of technical skills for the manufacturing of intermediate components of the needed quality standards. The quality of local supply of raw material, intermediate components and services to BPL is poor.

Financial constraints

Higher product cost due to infrastructural and services bottlenecks:

Since using an energy efficient technology in Indian refrigeration sector entails higher product cost, market competitiveness gets more adversely affected, if other production related costs are higher than optimal.

There is no capital availability problem for BPL. Since BPL's market is small, the cost--benefit analysis indicates that huge investment in research and development is not advisable at this stage. Credit supply has not been a problem for a well-established company such as BPL.

However, credit supply it is a constraint for local, small and medium scale enterprises which supply intermediate components. The special credit line to modernize these ancillary units can accelerate the process of technology adaptation.

Uncertainties

The basic infrastructural facilities like power, transport, communications are poor and unreliable in India. Consequently, extra costs gets reflected in the product cost. BPL uses its own diesel-based power generation plant in the absence of supply from the local utility. Higher inventory costs arise due to transportation uncertainties and delays in imports clearances.

The poor power quality is a constraint on energy efficient technology development. Although BPL has a more energy efficient compressor technology than other manufac-

turers still there are limitations. The compressor's energy efficiency ratio is not optimized at customer's end due to the poor power supply conditions in India.

For an Indian consumer a refrigerator is a life time purchase and the compressor reliability is more important than energy consumption for the consumer. Thus the compressors are designed to work under wide voltage fluctuating conditions ranging from 160V-260V which results in their relatively lower EER than the compressors of similar design abroad.

Regulation

Indian standards formulated for refrigerator testing as per IS1479 appear to be significantly behind international standards. The Bureau of Indian Standards itself lacks the credibility so much so that even if it improves the Indian standards, their implementation may not be effective.

A national technology centre with all the modern hardware and software testing infrastructure needs to be established. Such an institution should evolve energy consumption norms and also issue energy labels to the refrigerator manufacturers after testing their products. The reliability may remain a problem.

There is a need to introduce tax incentives for energy efficiency as has been done in the United States. Saving by energy efficiency contribute to national saving.

Consumer awareness

Dealers and customers do not appreciate that higher costs of energy efficient refrigerators can be recovered in 3-4 years through savings in household electricity consumption. The BPL refrigerator brings an estimated energy saving of 0.5 unit/day. This implies a saving of Rs 30 per month or Rs 360 per year. Thus in four years approximately Rs 1440 can be saved providing the compensation for higher product cost.

Four explanations of the disbelief are circulating. There is a lack of sensitivity among consumers and policy makers for environment degradation. There is a lack of knowledge about means to the environment. There is an absence of consumer incentives to buy environment friendly products. There is no mechanism to certify energy efficient commodities.

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